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CURRENT SERIAL RECORDS

SEED COTTON AND COTTONSEED HANDLING WITH AIR-JET CONVEYORS

Roy V. Baker and Victor L. Stedronsky[1/]

INTRODUCTION

Conveying seed cotton, lint, cottonseed, and trash are very important functions at modern cotton gins. Pneumatic conveying systems are used to unload seed cotton from farm trailers and convey it through the various stages of drying and cleaning to the gin stand. Lint is also pneumatically conveyed from the gin stand to the lint cleaners and bale press. A combination of mechanical conveyors and pneumatic conveyors is used to convey cottonseed and trash from the gin building to outside collection facilities. All this conveying requires considerable energy and accounts for a substantial part of the equipment and power used at cotton gins.

The high power consumption of pneumatic conveying systems is caused largely by their inherent inefficiency. The gin fans used to supply air for these systems are usually less than 50-percent efficient. Air turbulence, pipe friction, and air leakages further reduce the operating efficiency of pneumatic conveying systems.

Power surveys of cotton gins have shown that 50 to 65 percent of the total power used in the ginning process is consumed by fans. Most of this fan power is used by the pneumatic conveying systems. Modern high-capacity gins use from 300 to 600 horsepower for their various conveying systems.[2/] These figures include the drying processes, which are also pneumatic.

Increased power consumption in high-capacity gin plants is a major contributor to the rising costs of operating a cotton gin. Ginners who are trying to reduce their operating costs recognize the importance of reducing power cost. The most obvious way to reduce power cost is to use less power. One way this can be done is to use an alternate means of conveying that is more efficient than pneumatic conveying. Since pneumatic conveying in closed pipes consumes most of the power used in the ginning process, a reduction in this area would result in significant savings in power costs.

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2/ Wilmot, C. A., Stedronsky, V. L., Looney, Z. M., and Moore, V. P. Engineering and economic aspects of cotton gin operations...Midsouth, West Texas, Far West. U.S. Dept. of Agr., Agr. Econ. Rpt. 116, 43 pp. 1967.

The Southwestern Cotton Ginning Research Laboratory at Mesilla Park, N. Mex., has been testing a method of conveying that potentially could be utilized more efficiently than enclosed pneumatic conveying pipes. Its use in cotton gins would substantially reduce the power required for conveying. This method, air-jet conveying, is new to the ginning industry but has been used by other industries in the past.[3/] [4/]

The air-jet conveying principle is very simple. A series of air jets are used to lift and propel material along a sheet metal trough (fig. 1). The

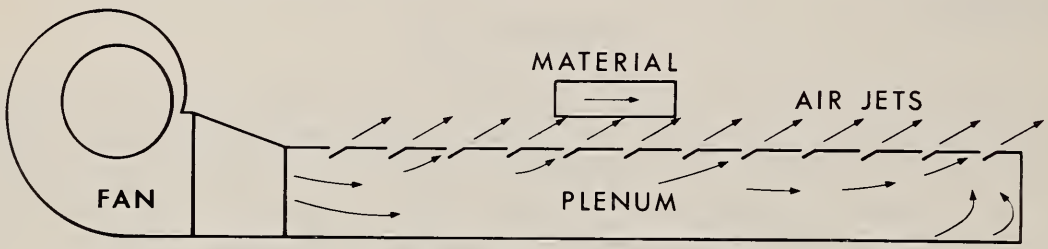

Figure 1. Schematic diagram of air-jet conveying principle.

bottom of the trough contains small louver-like openings through which the high-velocity air jets discharge. Pressurized air is supplied to the openings by a low-pressure centrifugal fan discharging into a plenum which underlies the entire trough area. Pressure in the plenum forces air out the openings at a high velocity. The openings in the trough are designed so as to direct the air jets at an angle with the horizontal. Air jets lift the conveyed material off the trough bottom and float it along on a cushion of air. With this method, sliding friction between the conveyed material and the trough bottom is virtually eliminated.

LABORATORY INVESTIGATIONS

Laboratory investigations of the air-jet conveying principle were undertaken in 1964 to determine the feasibility of using this type of conveyance in a cotton gin. The general areas investigated included (a) plenum airflow characteristics, (b) jet-slot airflow characteristics, (c) capacity of air-jet conveyors to handle seed cotton and cottonseed, (d) conveying ability of various jet-slot arrangements, and (e) horsepower requirements.

Plenum Airflow Characteristics

A series of measurements was made to gain more information on airflow inside the plenum of air-jet conveyors. Air velocity, static pressure, and total pressure measurements were made inside the plenums of an 18-inch-wide and a 6-inch-wide conveyor at equally spaced intervals along their entire

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3/ Alden, John L. Design of industrial exhaust systems. (See pp. 223 and 224.) 252 pp., Industrial Press, New York. 1939, revised 1948.

4/ Engineers Associated, Inc. Jetstream. 7 pp., illus. Oakland, Calif. 1960.

length (fig. 2). At each of these measuring points, the discharge air-jet velocity from the jet slots was also measured. These measurements were made at various airflow rates on several conveyors ranging from 10 feet to 40 feet long.

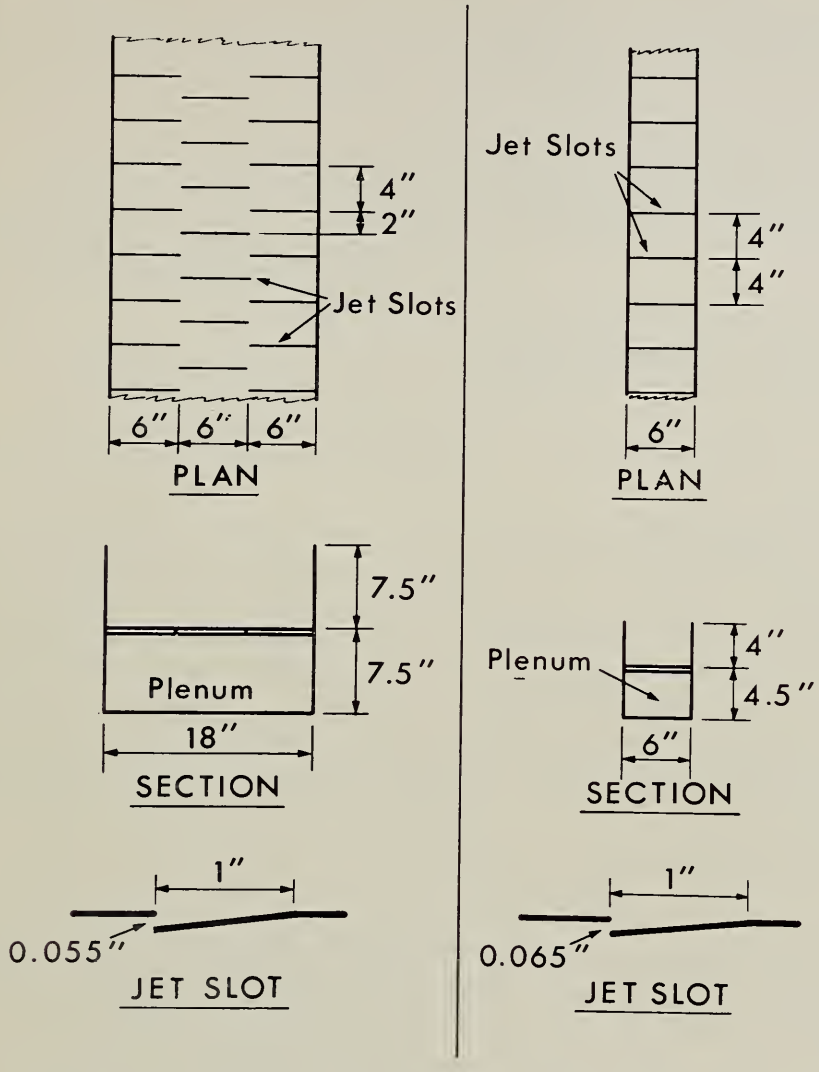

Figure 2. 18-inch-wide and 6-inch-wide air-jet conveyors used in these investigations.

Typical airflow and pressure characteristics determined as a result of these measurements are shown in figure 3. The total volume of air required for the entire length of conveyor was introduced into one end of the plenum. The volume of air flowing inside the plenum was progressively reduced by the continual discharge of air from the jet slots along the conveyor length. For a plenum of constant cross-sectional area, the decreasing air volume resulted in a gradual reduction in air velocity inside the plenum. For this reason the average velocity pressure in the plenum was at a maximum at the air-inlet end and decreased to zero at the opposite end.

The velocity pressure and static pressure of the air flowing in the plenum are interrelated. A change in one of these pressures produces a corresponding change in the other. A reduction in velocity pressure results in an increase in static pressure. This phenomenon is known as static pressure regain and is basically the application to airflow of the fundamental law of

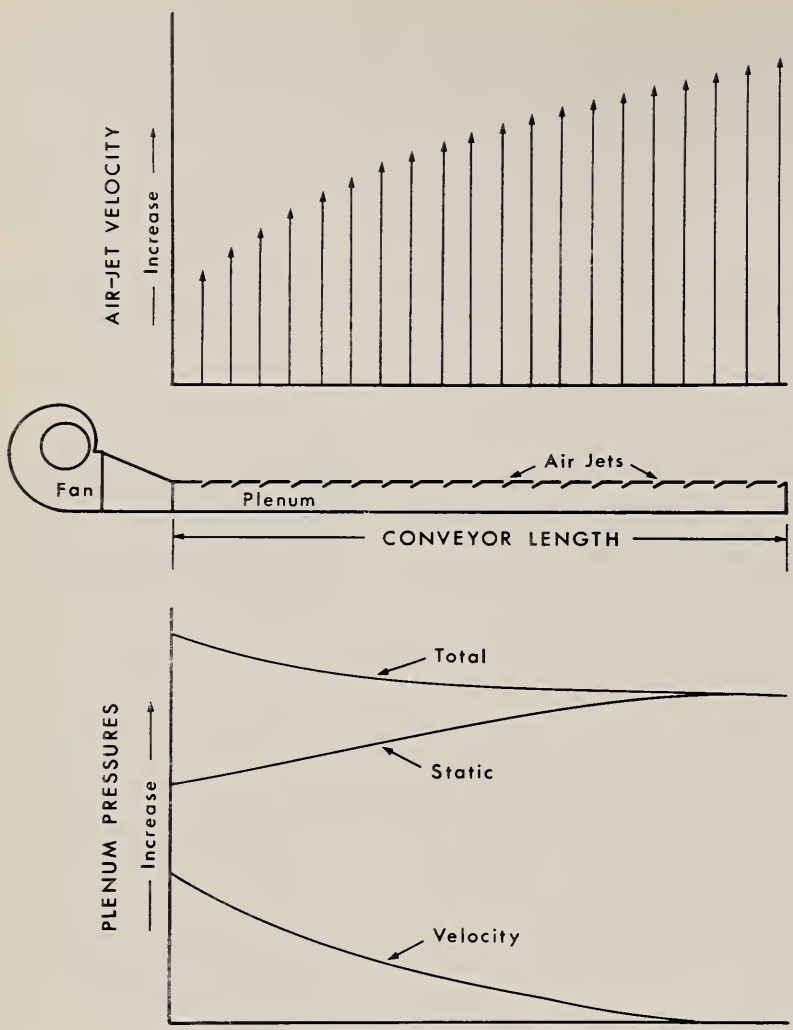

Figure 3. Typical airflow characteristics of air-jet conveyors.

conservation of energy. In the absence of friction and turbulence, the increase in static pressure would be equal to the decrease in velocity pressure. However, the theoretically perfect conversion of velocity pressure to static pressure never occurs because invariably air in motion loses energy due to friction and turbulence. For this reason the increase in static pressure is always less than the corresponding decrease in velocity pressure by an amount equal to the energy loss. The pressure conversions occurring in the plenums of the air-jet conveyors resulted in a steady increase in static pressure along the length of the conveyors. The static pressure was lowest at the air-inlet end and increased to its highest value at the downstream end.

The algebraic sum of the velocity and static pressures is known as the total pressure. As can be seen from figure 3, the average total pressure at the air-inlet end of the plenum was higher than at the downstream end. This total pressure loss was due to the friction and turbulence created by the air flowing through the plenum. The magnitude of these losses depended upon the cross-sectional area of the plenum, the length of the conveyor, and the velocity of the air in the plenum. Total pressure losses increased as conveyor lengths and air velocities became larger. Small plenums were also conducive to higher total pressure losses.

These losses must be considered in designing air-jet conveyor systems so that the correct size of centrifugal fan for a given conveyor system can be properly selected. This information is also important in determining the correct fan speed and motor size of the selected fan. For these reasons the data obtained from the measurement tests were used to determine a method for estimating the extent of total pressure losses associated with the flow of air in various sizes and lengths of plenums.

These measurements showed that for a given size and length of plenum the total pressure loss was proportional to the velocity pressure measured at the plenum inlet. This relationship is shown in the following equation:

$$F = .2VP + KVP \qquad \text{(equation 1)}$$

where

F = total pressure loss, inches of water
K = dimensionless factor dependent upon the size and length of the plenum
VP = inlet velocity pressure, inches of water

The first part of the equation, .2VP, is the type of expression normally used in fluid-flow analysis to determine the total pressure losses due to turbulence. These losses are commonly called shock losses. In this series of tests the shock losses were found to be independent of the size and length of the plenum used for testing. Whether this finding would be true for other sizes and lengths of plenums could not be determined from the tests. However, we believe that the range of these tests would encompass most conveyors that would be suitable for use in cotton gins. Therefore, for practical design purposes the shock-loss expression .2VP should be adequate for most ginning applications.

The second part of the equation, KVP, represents the loss in total pressure due to the frictional resistance of the plenum. This is the same type of relationship that is used to determine friction losses in conventional closed-pipe air handling systems. For air piping, where airflow is constant along the entire length, the friction loss can be determined from well-established friction-loss charts.[5/] These charts are solutions of basic friction-loss equations. These charts can also be used to determine the friction loss in the plenum of an air-jet conveyor even though the airflow is not constant along the entire length. The friction loss (KVP) in an air-jet conveyor plenum was found to be approximately one-fourth of the friction loss in an air pipe of equal size and length. Therefore, to obtain the friction loss (KVP) in a plenum, the standard charts can be used in the normal manner except that the loss obtained from these charts should be divided by four. This loss determination is based on the total air volume at the inlet of the plenum.

The total pressure loss in a plenum can be determined by calculating the shock loss and the friction loss as previously outlined. The sum of these two losses is equal to the total pressure loss due to airflow inside the plenum.

5/ Jorgensen, Robert. Fan engineering. Ed. 6, 700 pp., illus. Buffalo, New York 1961. (See page 100.)

Jet-Slot Airflow Characteristics

The velocity of the air discharging from a jet slot is a function of the plenum pressure directly under the slot. To learn more about this relationship, we conducted a series of tests in which the air-jet velocities from several sizes of jet slots were measured under varying plenum-pressure conditions. All the slots were 6 inches long and ranged in opening size from 0.025 to 0.090 of an inch.

These measurements revealed that the principal influence on the air-jet velocity was the static pressure in the plenum directly under the jet slot. Since the static pressure varied along the length of the plenum, air-jet velocities from individual jet slots along the length also varied. The air-jet velocity from individual jet slots increased as the plenum static pressure increased and reached its highest value at the downstream end of the conveyor where the plenum static pressure was the highest (fig. 3). Although static pressure was the major factor influencing jet-slot discharge, air velocity in the plenum was also found to have an influence. It was found that plenum air velocities in the direction of the air jet increased the air-jet velocities while plenum air velocities in the opposite direction decreased the air-jet velocities. This approach velocity effect was important at the air-inlet end of the plenum where the plenum air velocities were high. At points further downstream the effect became negligible because of decreasing air velocities in the plenum.

Analysis of the data from these tests showed that the following conventional air discharge equation for an orifice or nozzle could be used to calculate the air discharge from a jet slot:

$$Q = 1096.5\ JA\sqrt{\frac{T}{D}} \qquad \text{(equation 2)}$$

where

Q = air discharge from a jet slot, cubic feet per minute

J = coefficient of discharge = 0.79 for a jet slot

A = jet-slot area, square feet

T = total pressure in the plenum acting upon the jet slot, inches of water

D = air density, pounds per cubic foot

Substitution of the basic airflow equation, Q = AV, into the above expression produces

$$V = 1096.5J\sqrt{\frac{T}{D}} \qquad \text{(equation 3)}$$

where

V = air-jet velocity, feet per minute

The coefficient J in the above expressions was equal to 0.79 for all the jet slots investigated. The total pressure T in the above expressions is the total pressure acting upon the jet slot and includes the effects due to plenum approach velocity.[6/] At the downstream end of the plenum the total pressure is equal to the plenum static pressure because the air velocity in the plenum is zero at this point.

Conveying Capacity

Tests were conducted to investigate the seed cotton and cottonseed conveying capacity of three air-jet conveyors of different widths, each of which was subjected to varied test conditions. The seed cotton tests were run on a 15-inch-wide and an 18-inch-wide conveyor. A 6-inch-wide conveyor was used for testing upland and Pima cottonseed. The 6-inch-wide and 18-inch-wide conveyors were also tested at inclined angles up to 45 degrees (fig. 4). The seed cotton used in these tests was machine picked and had a moisture content of approximately 5 percent and a foreign matter content of 10 percent. The linters content of the upland and Pima cottonseed was 10.5 percent and 2 percent, respectively. Each conveyor was tested under different conditions at several material loadings, and the minimum air-jet velocity that would convey the cottonseed and seed cotton at each loading was measured. This velocity was the critical air-jet velocity required for conveying. The results of these tests represent maximum conveying capacities measured for each set of test conditions. The conditions under which the conveyors were tested and a summary of the results are given in table 1.

These tests showed that the higher the material loading, in pounds per hour per inch of conveyor width, the higher the critical air-jet velocity required for conveying. For example, cottonseed required higher velocities than seed cotton. Slightly higher velocities were needed for conveying Pima cottonseed than upland cottonseed. Presumably, the velocity requirement varied because of the difference in the linters content of the two types of seed.

Conveying the loads up inclined angles required higher velocities than conveying them horizontally, and the steepest inclines required the highest critical air-jet velocities. The percentage increase in air-jet velocity for the various inclined conveyor setups tested is shown in table 2.

6/ The total pressure acting upon the jet slot is not necessarily equal to the average total pressure in the plenum. The difference between the two is caused by a variation in the air velocity between the middle and the top of the plenum. This difference is greatest at the air-inlet end of the plenum and becomes negligible at the downstream end. The total pressure acting upon a jet slot was measured by placing a small box over the entire slot and measuring the pressure inside the box. This pressure was equal to the total pressure acting upon the slot and may be used in the above equation to determine air discharge from that slot. When this method is used, care should be taken to provide an airtight seal between the measuring box and the conveyor surface.

Figure 4. Conveying seed cotton up a 30-degree incline with an 18-inch-wide air-jet conveyor.

Table 1. Maximum capacities of three widths of air-jet conveyors transporting seed cotton and cottonseed.

Material conveyed	Conveyor				Jet slot		Critical air-jet velocities[1/] for conveying capacities[2/] of--			
	Horizontal length	Inclined length and angle		Width	Spacing	Opening	250 lb. per hr. per in.	500 lb. per hr. per in.	750 lb. per hr. per in.	1,000 lb. per hr. per in.
		Length	Angle							
	Feet	Feet	Degrees	Inches	Inches	Inch	Feet per minute	Feet per minute	Feet per minute	Feet per minute
Seed cotton	20	0	0	18	4.00	0.055	2,270	2,510	2,840	3,170
Do.----	10	10	30	18	4.00	.055	3,010	3,510	4,010	4,590
Do.----	10	10	45	18	4.00	.055	3,670	4,180	4,590	5,100
Do.----	15	0	0	15	2.75	.063	1,840	1,920	2,170	2,420
Do.----	15	0	0	15	2.88	.125	1,250	1,340	1,420	1,510
Upland cottonseed------	15	0	0	6	4.00	.065	4,590	5,510	6,010	6,420
Do.----	5	10	30	6	4.00	.065	5,260	6,180	6,920	7,260
Do.----	5	10	45	6	4.00	.065	5,920	6,920	7,600	8,180
Pima cottonseed------	15	0	0	6	4.00	.065	5,010	5,850	6,420	6,920

1/ Standard air.

2/ Conveying capacity in pounds per hour per inch of conveyor width.

Table 2. Air-jet velocity increases required for transporting seed cotton and cottonseed on inclined air-jet conveyors.

Material conveyed	Distance conveyed		Angle of incline	Air-jet velocity increase required for incline
	Horizontally	Inclined		
	Feet	Feet	Degree	Percent
Seed cotton	10	10	30	50
Upland cottonseed	10	10	30	15
Seed cotton	10	10	45	67
Upland cottonseed	10	10	45	25

For ginning applications, operating an air-jet conveyor at the capacities obtained in these tests would not be practical. These tests determined the maximum capacity obtainable under a given set of conditions. It would not be desirable at a cotton gin to operate at maximum capacity because at this level the conveyor is very near the point of chokage. Observations made during these and subsequent tests indicated that an air-jet conveyor could be operated satisfactorily at capacities of 50 to 75 percent of maximum.

In these tests the conveying capacity of an air-jet conveyor was directly proportional to its width. Under similar operating conditions, a conveyor 24 inches wide will convey twice as much material as one 12 inches wide. Desired conveying capacity, therefore, may be used to determine the required conveyor width. For an air-jet conveyor handling seed cotton and cottonseed, a material loading of 750 pounds per hour per inch of width appears to be a desirable rate for accomplishing the purposes of the conveyor design. This rate was used in calculating the recommended conveyor widths shown in table 3. This table was prepared to assist ginners in selecting adequate conveyor widths for conveying machine-picked seed cotton and cottonseed at various ginning rates.

Jet-Slot Arrangement

The jets of air discharging from the conveyor trough bottom provide the forces required to move material along the trough to a desired destination. Size, arrangement, shape, and force of the air jets determine their ability to convey a given material. An investigation was conducted of the interrelationship of these factors in an attempt to determine the combination of factors most suitable for use in ginning applications. In this series of tests, various combinations of slot-opening size, slot spacing, and air-discharge angle were tested. For each of these combinations, measurements were made to determine the critical discharge velocity of air required to convey a given material. The material to be tested was placed on the conveyor surface, and the air velocity was gradually increased until the material began to move. This discharge velocity was taken as the critical conveying condition for that material. The materials conveyed in these tests were seed cotton,

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Table 3. Recommended air-jet conveyor widths for various cotton ginning rates.

Ginning rate[1/] (bales per hour)	Seed cotton conveyor width	Cottonseed conveyor width
	Inches	Inches
6 or less--------	12	6
6 to 9----------	18	12
9 to 12----------	24	15
12 to 15---------	30	18
15 to 18---------	36	21
18 to 21---------	42	24
21 to 24---------	48	30

1/ Based on a material-loading rate of 750 pounds per hour per inch of width.

Pima cottonseed, and upland cottonseed. The weight, shape, and density of each of the materials were constant for all test setups. This permitted the determination, for each test combination, of the critical discharge velocity required to produce equal conveying results.

The following magnitudes were tested for the three variables--slot-opening, slot spacing, and air discharge angle:

Slot-opening size	Slot spacing	Air discharge
Inch	Inches	Degrees
0.029	2	2.5
.063	4	3.2
.089	6	4.5
.144	8	8
.164	10	14

The results of these tests showed that a definite relationship existed between slot-opening size, slot spacing, and critical discharge velocity for a given material. Within the range of 2.5 to 14 degrees the air discharge angle did not significantly influence critical discharge velocity. This finding applied to both horizontal and inclined conveyors. The following relationship was determined from this investigation:

$$V' = Ck \frac{S^{0.4}}{W^{0.6}} \qquad \text{(equation 4)}$$

where

V' = critical discharge velocity, feet per minute
C = a coefficient characteristic of the material being conveyed
k = kinematic viscosity of conveying air, feet squared per second
S = slot spacing, inches
W = slot-opening size, inches

The critical discharge velocity, as determined form this equation, is the average velocity of the air discharging from a jet slot. It is apparent from this equation that the critical discharge velocity required to convey a given material is not constant but is dependent upon jet-slot size and spacing. In these tests the critical discharge velocity was directly proportional to the slot spacing raised to the 0.4 power and inversely proportional to the slot-opening size raised to the 0.6 power. The kinematic viscosity of the conveying air is influenced primarily by temperature and air density. For various temperature and density conditions, the correct kinematic viscosity can be obtained from several engineering handbooks.[7] For standard air (70° F. and 0.075 pound per cubic foot), the kinematic viscosity is 1.63×10^{-4} feet squared per second.

These tests showed that satisfactory conveying could be accomplished by a wide range of jet-slot opening sizes and spacings. However, jet slots with an opening size of one-sixteenth to one-eighth inch and spaced 4 to 8 inches apart appear to be the most practical and economical for conveying seed cotton and cottonseed. The air discharge angle had no effect upon conveying ability as long as the angle was smaller than 15 degrees.

The value of the coefficient C appearing in equation 4 was found to be independent of the conveyor width, jet-slot spacing, and jet-slot-opening size. The value of C depended upon the type of material being conveyed. Further investigations showed that C also depended upon the material-loading rate. Values of C for seed cotton, upland cottonseed, and Pima cottonseed were calculated from the results of the previously described conveying capacity tests. These calculations were based on a horizontal conveyor operating at 50 percent of maximum conveying capacity. The values of the coefficient C determined from these calculations are shown in figure 5. These values can be used in equation 4 to calculate the air-jet velocities required to accomplish conveying with various sizes and spacings of jet slots. The required air-jet velocities for several combinations of jet-slot-opening sizes and spacings were calculated by this method and are shown in table 4. Air-jet velocities determined in this manner are calculated for horizontal conveyors.[8]

Horsepower Requirements

The horsepower requirements of an air-jet conveyor are determined by the total volume of conveying air and the total pressure at the plenum entrance. The air horsepower for an air-jet conveyor can be calculated from the following expression:

7/ Jorgensen, Robert. Fan engineering. Ed. 6, 700 pp., illus. Buffalo, N. Y. 1961. (See p. 66.)

8/ For inclined conveying, higher air-jet velocities are required than for horizontal conveying. Inclined conveying of seed cotton and cottonseed has been investigated only to a limited extent. Consequently, detailed information on the required air-jet velocities for various inclined conveyor setups is not yet available. (See table 2.)

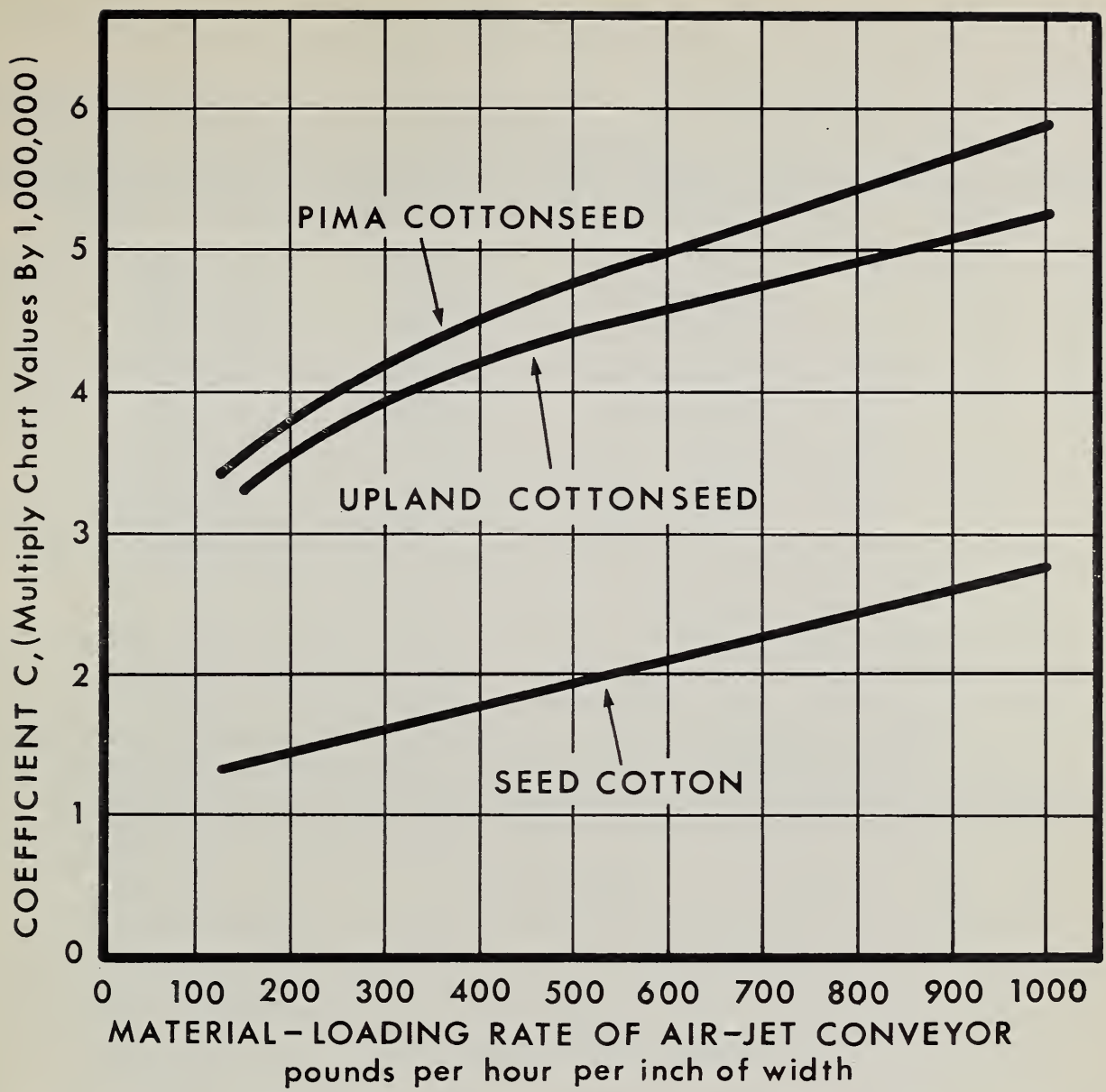

Figure 5. Values of coefficient C for conveying seed cotton, upland cottonseed, and Pima cottonseed at various material-loading rates.

$$AHp = \frac{CFM \times TP}{6356} \qquad \text{(equation 5)}$$

where

AHp = air horsepower
CFM = volume of conveying air, cubic feet per minute
TP = total pressure at plenum entrance, inches of water

Table 4. Calculated critical air-jet velocities for the horizontal conveying of seed cotton, upland cottonseed, and Pima cottonseed[1/]

Jet-slot spacing (inches)	Jet-slot-opening size	Critical air-jet velocities[2/] for--		
		Seed cotton	Upland cottonseed	Pima cottonseed
	Inch	Feet per minute	Feet per minute	Feet per minute
4-------	1/16	3,560	7,240	7,880
6-------	1/16	4,200	8,550	9,280
8-------	1/16	4,700	9,540	10,400
4-------	3/32	2,780	5,650	6,160
6-------	3/32	3,260	6,640	7,220
8-------	3/32	3,670	7,480	8,120
4-------	1/8	2,340	4,760	5,180
6-------	1/8	2,750	5,600	6,100
8-------	1/8	3,090	6,290	6,850

1/ Based on rates of 750 pounds per inch of width with conveyor operating at 50 percent of capacity.
2/ Standard air.

The air horsepower requirements for a typical air-jet conveyor are shown in table 5. This information was calculated by using the above expression. The driving power required by the centrifugal fan for an air-jet conveyor can be determined as follows:

$$\text{Fan Hp} = \frac{\text{AHp}}{E} \times 100 \qquad \text{(equation 6)}$$

where

E = fan mechanical efficiency in percent (30 to 50 percent for gin fans)

GINNING APPLICATIONS

A number of possible ginning applications can be made from the air-jet conveyor principle. The Southwestern Cotton Ginning Research Laboratory has tested two applications that appeared to be the most feasible. A small-scale seed cotton unloading system using an air-jet conveyor and a cottonseed conveying system has been investigated.

The pilot model of a seed cotton unloading system was tested with encouraging results.[9/] This system consisted of a side dumping trailer, receiving hopper, and air-jet conveyor and was designed to replace the conventional suction-pipe unloading system. Seed cotton was dumped out of the trailer into a hopper. In addition to holding the trailer load of cotton, the hopper

9/ Baker, R. V., and Stedronsky, V. L. An improved unloading system for gins. The Cotton Gin and Oil Mill Press, 66(7):50-51, illus. 1965.

Table 5. Air horsepower requirements for conveying seed cotton and cottonseed in an 18-inch-wide air-jet conveyor.[1/]

Average air-jet velocity[2/] (feet per minute)	Air horsepower for conveyor lengths of--			
	10 feet	20 feet	30 feet	40 feet
	Horsepower	Horsepower	Horsepower	Horsepower
3,000----------	0.10	0.21	0.33	0.48
4,000----------	.24	.49	.78	1.13
5,000----------	.46	.95	1.52	2.22
6,000----------	.80	1.65	2.62	3.84
7,000----------	1.27	2.62	4.18	6.08
8,000----------	1.88	3.90	6.22	11.2

1/ Air-jet spacing = 4 inches; air-jet opening size = 1/16 inch; plenum cross section = 8 inches by 18 inches.
2/ Standard air.

was also equipped to feed the seed cotton to the air-jet conveyor at a uniform rate. In this manner seed cotton could be unloaded from the trailer and conveyed into the gin building with a minimum of power. The operation of the pilot model system indicated that this type of unloading system would use only about 20 percent of the horsepower required by a conventional system. The construction of a full-scale unloading system employing this technique has been initiated at the laboratory. Upon completion, this system will be evaluated under actual ginning conditions.

An air-jet conveyor 6 inches wide was installed in the laboratory saw ginning system for the purpose of conveying cottonseed from the 80-saw gin stand to a small-pipe seed blowing system. The air-jet conveyor replaced a conventional 8-inch-wide seed belt conveyor. The conveyor was approximately 17 feet long (fig. 6). A small centrifugal fan provided 800 cubic feet of air per minute to the conveyor. The fan, driven by a 3/4-horsepower motor, was working against a static pressure of 2.5 inches of water. The conveyor's jet slots were 6 inches wide with an opening size of one-sixteenth inch. The slots were spaced 4 inches apart.

The air-jet conveyor handled upland cottonseed at a conveying rate of 1,300 to 1,800 pounds per hour. It operated satisfactorily throughout the 1966-67 and 1967-68 ginning seasons and had advantages over the belt conveyor of simplicity and safety.

RECOMMENDATIONS FOR FUTURE RESEARCH

The application of the air-jet conveying principle to cotton ginning requires a thorough knowledge of the characteristics and capabilities of the conveyor under a variety of operating conditions. Investigations to date have answered a number of these critical questions, but by no means all of them. Several areas of this problem that need further investigation are--

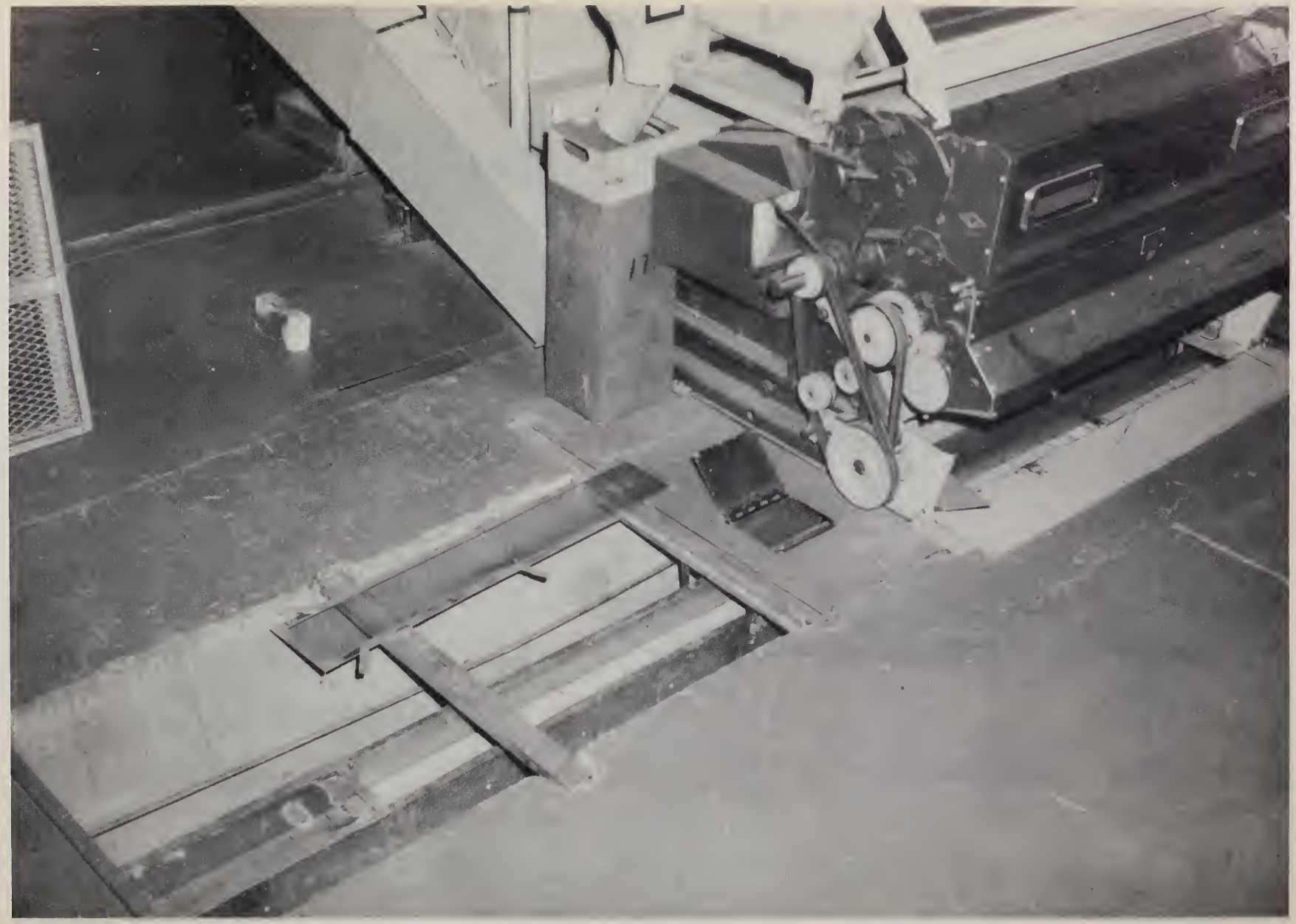

Figure 6. Air-jet seed conveyor installed under an 80-saw gin stand.

1. The conveying of machine-stripped seed cotton, gin trash, and ginned lint which has not been investigated.

2. Further investigation of conveying up inclined angles, an area where study is needed in order to properly design complete conveyor systems.

3. The possible use of the air-jet conveyor as a moisture conditioner for seed cotton and lint, an application that merits further consideration.

4. The use of covers over the conveying trough to prevent air contamination and material losses, a potentially desirable feature that needs further investigation.

SUMMARY

Materials-handling operations at cotton gins consume about half of the total power required for operating the ginning system. Often, as much as 600 horsepower is required for the materials-handling operations alone. Much of this high power consumption is due to the use of pneumatic closed-pipe conveying systems, which are usually very inefficient. High power consumption and the corresponding high electric power costs are becoming very burdensome to modern cotton gins. As a result, increased efforts are being made to lower power consumption in ginning.

Materials handling is obviously one of the areas needing improvement. In 1964, the Southwestern Cotton Ginning Research Laboratory at Mesilla Park, N. Mex., began investigating a method of conveying that could potentially reduce the power required for the materials-handling operations at cotton gins. This method, air-jet conveying, is accomplished by a series of high-velocity air jets discharging from slots in the bottom of a conveying trough that lift material off the trough surface and float it along on a cushion of air. A fan blows air into a plenum underlying the entire trough area and forces the air out the slot openings at a high velocity. Laboratory tests have shown that air-jet conveyors are capable of handling the volumes of seed cotton and cottonseed generally encountered at gins. Seed cotton conveying by the air-jet method was accomplished with substantially less power than with conventional methods. The use of air-jet conveyors to replace mechanical cottonseed conveyors was found to offer advantages of simplicity and safety, but no real savings in power.

Laboratory investigations of air-jet conveying were conducted in the following general areas: (a) Airflow characteristics; (b) conveying capacity; (c) conveying ability of various jet-slot arrangments; and (d) power requirements.

Tests showed that air flowing through the plenum loses some of its energy because of friction and turbulence. These energy losses produce a total pressure loss inside the plenum that must be considered in designing air-jet conveyor systems. A means of predicting these losses was determined and found to be satisfactory for use in the design of conveyor systems for cotton gins.

The volume of air discharging from a jet slot was found to vary directly with the slot area and with the square root of the air pressure in the plenum acting upon the jet slot. An equation was determined from which air discharge rates can be calculated for different size jet slots under various plenum air pressures.

Conveying capacity tests were conducted on several air-jet conveyor arrangements. These tests showed that the higher the material loading, in pounds per hour, the higher the air-jet velocity required for conveying. Conveying up inclined angles required air-jet velocities 15 to 67 percent higher than horizontal conveying. Conveying cottonseed required higher velocities than seed cotton conveying, and Pima cottonseed required higher velocities than upland cottonseed. An expression was obtained from which the air-jet velocity required to convey seed cotton, Pima cottonseed, and upland cottonseed at various rates could be calculated for different arrangements of jet-slot-opening sizes and spacings.

Various jet-slot-opening sizes, spacings, and air-jet discharge angles were tested to determine a combination suitable for ginning applications. When it varied from 2.5° to 15°, the air-jet discharge angle had no effect upon the conveyor's ability to move seed cotton and cottonseed. Jet-slot-opening size and spacing, however, were found to have a definite relationship to the air-jet velocity required to accomplish conveying. The air-jet velocity required to convey a given material was directly proportional to the slot spacing raised to the 0.4 power and inversely proportional to the slot-opening size raised to the 0.6 power.

The horsepower requirements of an air-jet conveyor depend upon the total volume of conveying air and the total pressure at the plenum entrance. The conventional air horsepower formula may be used to calculate the power requirements of various air-jet conveyor setups.

Two practical applications of air-jet conveying to ginning were tested. A pilot model of a seed cotton unloading system using an air-jet conveyor to convey seed cotton from an unloading point to the gin building was tested with good results. A cottonseed air-jet conveyor was installed under an 80-saw gin stand as a replacement of a conventional belt-type conveyor. This installation operated satisfactorily and was found to have the advantages of simplicity and safety over the conventional belt or auger conveyor.

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